# Impacts of Lameness, Longevity & Inflammation on Productivity & Management of the Sow Herd

Mark E. Wilson Ph.D., Zach J. Rambo, Ph.D. and Melanie K. Beckman, MS.

Zinpro Corporation, 10400 Viking Drive, Suite 240, Eden Prairie, MN 55344 USA
mwilson@zinpro.com

## 1. Introduction

Causes of lameness are a complex combination of issues that have been investigated. Poor skeletal structure, claw lesions, inferior environmental conditions, diseases such as osteochondrosis or mycoplasma hyosynoviae, and improper handling all are potential contributors to lameness. Lameness, locomotion problems, and age are some of the more common reasons for culling. Reproductive failure and lameness are the two most common reasons for culling gilts and parity-one sows. In the United States, culling and death loss numbers have risen in many systems in the last several years. Some of this increase in death loss is due to euthanasia of lame sows which are no longer accepted at meat processing facilities. The lack of gilts making it to at least parity three creates challenges in maintaining breeding target numbers. A common on-farm approach is to either increase the number of gilts selected or keep lower productivity sows to meet the breeding target.  Bringing in high numbers of gilt replacements increases the risk of destabilizing herd health. In addition, progeny from gilts do not perform as well as progeny from sows of parity two through five. The goal in swine production is not to heal lameness, but to improve horn production such that it will mitigate the effects of and decrease the amount of lameness. The purpose of this paper and presentation is to detail a series of research trials demonstrating the impact of different sources of minerals on specific types of epithelial tissue. These studies will show differences in inflammation and productivity, focusing on claw tissue and also the barrier function of the intestinal tract, when feeding different trace mineral sources.

## 2. Lameness

The impact of livestock lameness is not limited to the swine industry, but the challenge of swine lameness is unique. Dairy cattle locomotion studies have found large impacts on milk production, as severity of locomotion scores increase. However, dairy producers have a distinct advantage over swine producers, as they can quickly observe the impact lameness has on milk volume at the parlor. The impacts of swine lameness are harder to tease out, and may be just as costly to production when they are investigated.

For the swine producer, identifying lameness requires careful observation. Deviations in locomotion, such as head-bobbing, throwing shoulders or hips in a twisting motion, and refusal to stand or put weight on a foot are symptoms of lameness. Lame sows tend to have decreased feed intake, poor milk production, increased laid-on piglets, poor performance of progeny in grow-finish, and a higher percentage of death loss, compared to piglets from sows without lameness. A study was conducted at the University of Georgia to determine if trimming impacted locomotion of swine, as it does cattle and horses. The objective was accomplished by discerning the difference in sow gait, pre- and post-functional trimming. Fifty-two sows had claws trimmed to a length of 5.5 cm from the coronary band. Each sow was videotaped, using two high-speed cameras at three time points: pre-trim, one-hour post- and 48-hours post-trimming. Sows showed significant improvement in gait from pre- to 48-hours post-trimming. Positive changes in gait included a decrease in swing and stride duration, as well as break over, and increased swing:stance ratio and velocity (Tinkle *et al*., 2016). A second study investigating sow trimming was designed to understand the potential financial benefit of trimming 2 and 3 parity sows only once, versus not trimming toes longer than 6.0 cm in length. Three hundred and eighty sows per treatment were farrowed, showing a 0.4 pig increase in pigs born alive in the 2$^{nd}$ farrowing, and a 0.6 pig increase after the 3$^{rd}$ farrowing (DeDecker *et al*., 2016) for sows that were trimmed versus not-trimmed.

Data shows that claw lesions and lameness are reduced when Zn, Mn and Cu amino acid complexes are fed in the diet. Controlled research conducted by Anil et al. (2009) indicated that the inclusion of amino acid complex forms of Zn, Mn, and Cu, as a partial replacement for inorganic trace minerals, significantly reduced the overall frequency of claw lesions. Data from field observations on 15 farms in 4 different countries demonstrated that after 9 to 12 months of feeding Zn, Mn and Cu amino acid complexes, the number and severity of claw lesions were reduced.

## 3. Longevity

Economic models suggest greater economic value is captured by maintaining sows in the herd through parity five, and found little additional value for maintaining sows beyond the fifth parity. Dr. John Deen, University of Minnesota, recommends that measuring the proportion of animals remaining through early parities is a more important management metric than measuring the average herd parity. It has been expressed that the ideal range for profitability of % replacement rate is between 40 to 45%, however, many high-producing systems are above a 55% replacement rate. When consideration is given to the impact of gilt progeny, compared to sow progeny, there is an advantage in mortality, morbidity, birth weight, growth rate, and feed efficiency for piglets born and nursed by second to fifth parity sows. Estimates on the differences in growth rate from gilt progeny has been noted from 7%, up to as high as 17%. The differences in amount of IgG in colostrum and milk may partially explain the sow over gilt advantage, and additional research has shown that piglets born to gilts are lighter at birth compared to piglets born to multiparous sows. The combination of lower birth weight and less effective immunity transfer can explain a great deal of the variation in growth between pigs born to gilts versus multiparous sows. The need for large numbers of gilts entering the herd to maintain breeding targets may increase issues that destabilize herd health.

## 4. Inflammation

Inflammation, though difficult to measure in commercial circumstances, undoubtedly impacts productivity and the formation of claw tissues. Cell culture data shows that the inflammatory cytokines, tumor necrosis factor alpha (TNFa) and interleukin 1 alpha, decrease the proliferation of keratinocytes (Mulling et al., 2002). This suggests that the quality of horn tissue may be poorer and will reduce the proliferation of keratinocytes when inflammation is up regulated. How much of an impact do circulating cytokines from other regions of the body play on claws?

A deeper dive into gene expression and phenotypic response of corium tissue to help clarify the impacts of inflammation was addressed by the University of Illinois. Gene expression of 28 genes in corium tissue during the peripartum period was related to claw composition, oxidative stress, inflammation, chemotaxis and transcriptional factors (Osorio *et al*., 2017). Forty-four Holstein cows were fed a common diet for 30 days pre-calving and 30 days post-calving. Control cows were given a daily bolus of inorganic minerals, while treated cows were given a daily bolus of metal amino acid complexes. Mineral levels for both groups were iso for Zn, Mn, Cu, and Co, to achieve supplemental levels of 75, 65, 11, and 1 ppm of each mineral, respectively. Treatment levels of Zn, Mn, Cu, and Co in the boluses were 40, 20, 5, and 1 ppm, respectively. Milk production, weekly locomotion score, incidence of hoof lesions, and health indices were recorded. Milk production was greater ($P < 0.05$) in treated cows compared to control cows. Both treatments had a similar number and type of lesions, except for heel overgrowth and erosion in the control treatment. Here, 8 of 10 cows had greater severity of the lesion, while only 3 heels were overgrown in the metal amino acid complex treatment. There were no differences in locomotion scores for either treatment. Hoof biopsies were sampled on a subset of cows, showing a down-regulation in KRT5 (keratin 5), CTH (cystathionase), CALML5 (Ca binding messenger) and CYBB (Cytochrome b-245 β polypeptide), and the up-regulation of BTD in treated cows (Osorio *et al*., 2017). This suggests a decreased need for activation pathways to regenerate corium tissue, and increased biotin available for the sole of the claw. Treated cows had greater expression of NFE2L2, which regulates the antioxidant enzyme SOD1, reducing oxidative stress in the cytosol. Treated cows also had a lower expression of TLR2, IL1B, and TNF, which up regulate inflammation. Supplementation with metal amino acid complexes during the peripartal period affected the transcription of various genes responsible for influencing structure, oxidative stress, and inflammation status of the hoof. Dietary sources of either inorganic or metal amino acid complex minerals showed different responses of phenotype and gene expression.

Experiments demonstrating the impact of zinc amino acid complexes on intestinal barrier function during heat stress further demonstrate the relationship of protective epithelial tissue and interaction with the immune system. A series of growing-phase swine experiments conducted at Iowa State University showed that zinc amino acid complex has a very different response than zinc sulfate on barrier function, epithelial integrity, anatomical and histological damage of the villi, and gut leakage, due to acute heat stress (Sanz-Fernandez *et al*., 2014; Pearce *et al*., 2015). Immune competency is also greater with zinc amino acid complex, than with zinc sulfate. Pigs fed a partial replacement of zinc amino acid complex had significantly greater ($P < 0.05$) lipopolysaccharide binding protein (LBP), than heat stressed pigs fed solely zinc sulfate. In addition, feeding zinc amino acid complex reduced the amount of LPS (endotoxin) in the bloodstream (Pearce *et al*., 2015). In a third study, investigators demonstrated the impact of zinc amino acid complex on metabolism, biomarkers of leaky gut, and inflammation in heat-stressed and nutrient-restricted pigs. Fifty crossbred gilts were blocked by body weight and randomly assigned to one of five treatments: 1) Thermal neutral (TN), *ad libitum*; 2) TN, feed-restricted (FR); 3) TN, FR, zinc ; 4) Heat-stress (HS) control, *ad libitum*; and 5) HS, *ad libitum*, zinc amino acid complex. Three phases of production were used in the project: Phase 1) 7-day acclimation period under thermal neutral conditions (20° C); Phase 2) Environmental challenge of thermal neutral or heat stress (30° C day; 27° C night) conditions for 7 days; Phase 3) Recovery for all treatment groups, of TN *ad libitum* feeding of respective treatment diet. Pigs exposed to heat stress had an overall increase in rectal and skin temperature, along with respiration rate (0.33 °C, 3.76 °C, 27 breaths per minute, respectively; Mayorga *et. al.,* 2017). Heat stress decreased ADFI and ADG relative to thermal neutral controls ($P < 0.05$), but these variables were unaffected by dietary treatment. Circulating insulin levels decreased in nutrient-restricted animals compared to thermal neutral and heat stressed animals ($P < 0.03$). Nutrient-restricted pigs had increased ADFI and ADG relative to thermal neutral and heat stress treatments in phase 3 ($P<0.05$). During recovery, circulating insulin levels increased 75% ($P<0.05$) in pigs that were heat-stressed, compared to thermal neutral and nutrient-restricted pigs. Blood glucose tended to increase in pigs consuming zinc amino acid complex minerals, relative to inorganic minerals ($P < 0.07$). Plasma TNFα levels tended to decrease during Phases 1 and 3, in pigs fed zinc amino acid complex versus inorganic zinc. Zinc treatment appears to reduce TNFα regardless of heat stress, while the stimulatory effect of heat stress amplifies insulin secretion (Mayorga et al., 2017). This data supports the notion of a differential response in immune function and regulation between zinc sources.

## 5. Summary

Programs on the farm to reduce incidence of sow lameness need to be more than just a feeding program and subsequent ignoring of the problem. Positive responses to both livestock claws and hooves have been consistent with use of metal amino acid complex minerals. The outer horn grows at a rate between 3 to 7 mm per month and the outer horn wall, from the coronary band to the tip of the toe, is generally around 5.0 cm in length. If a lesion is near the top of the claw, it will take a minimum of 4 months to fully disappear. Amino acid complex minerals help support the immune system, helping corium and horn tissue proliferate and heal. Environment, flooring conditions (wet/manure-covered), sow movement and handling, and sow structure are all issues that contribute to locomotion and lameness. Metal amino acid complex minerals are a great choice to begin improving horn quality, epithelial strength, and repair, but it takes wisdom in culling and animal husbandry to do the best job of mitigating lameness in the sow herd.

## References

**Anil, S. S., J. Deen, L. Anil, S. K. Baidoo, M. E. Wilson and T. L. Ward.** 2009. Evaluation of the supplementation of complexed trace minerals on the number of claw lesions in breeding sows. Manipulating Pig Production XII, Australasian Pig Science Association. Cairns, Australia, November 22-25, pp. 108.

**DeDecker A., X. Martinez, E. Benitez, T. Coffey, J. Torrison, Z. Rambo, M. Wilson, M. Parsley.** 2016. Effect of trimming long toes of sows on longevity, productivity, and economic return. IPVS 24th International Pig Veterinary Society Congress. Royal Dublin Society. Dublin, Ireland, June 7-10, Proceedings: Herd Health Management and Economy: O-HHM3-012, pp. 153.

**Mayorga, E. J., S. K. Kvidera, E. A. Horst, M. Al-qaisi, Z. Rambo, M. Wilson and L. H. Baumgard.** 2017. Effects of zinc amino acid complex on biomarkers of gut integrity and metabolism during heat stress and a following recovery period in growing pigs. Midwest ASAS, Omaha, NE, March 13-15.

**Mülling, C. H., D. Hoffmann and K-D. Budras.** 2002. *In vitro* challenge studies on the effects of cytokines and growth factors on bovine keratinocytes. Institute of Veterinary Anatomy, Freie Universität Berlin, Koserstr. 20, D-14195, Berlin, Germany

**Osorio, J. S., F. Batistel, E. F. Garrett, M. M. Elhanafy, M. R. Tariq, M. T. Socha, and J. J. Loor.** 2017. Corium molecular biomarkers reveal a beneficial effect on hoof transcriptomics in peripartal dairy cows supplemented with zinc, manganese, and copper from amino acid complexes and cobalt from cobalt glucoheptonate. J. Dairy Sci. 99:9974–9982.

**Pearce, S. C., M. V. Sanz-Fernandez, J. Torrison, M. E. Wilson, L. H. Baumgard, and N. K. Gabler.** 2015. Dietary zinc attenuates heat-stress induced changes in intestinal integrity and metabolism. J. Anim. Sci. 93:4702-4713.

**Sanz-Fernandez, M. V., S. C. Pearce, N. K. Gabler, J. F. Patience, M. E. Wilson, M. T. Socha, J. L. Torrison, R. P. Rhoads, and L. H. Baumgard.** 2014. Effects of supplemental zinc amino acid complex on gut integrity in heat-stressed growing pigs. Animal 8(1):43-50.

**Tinkle, A. K., K. J. Duberstein, M. E. Wilson, M. A. Parsley, M. K. Beckman, J. Torrison, M. J. Azain, and C. R. Dove.** 2016. Functional claw trimming improves the gait and locomotion of sows. Livest. Sci.195:53-57.